Enhanced Multi-Objective Optimization of Groundwater Monitoring Networks

Bode, Felix; Binning, Philip John; Nowak, Wolfgang

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NGWA Groundwater SUMMIT 2014

Enhanced Multi-Objective Optimization of Groundwater Monitoring Networks

Tuesday, May 6, 2014: 3:20 p.m.
Blake (Westin Denver Downtown)

***Felix Bode** , Department of Hydromechanics and Modelling of Hydrosystems, University of Stuttgart, Stuttgart, Germany*
Philip Binning , Department of Environmental Engineering, Technical University of Denmark, Lyngby, Denmark
Wolfgang Nowak , Department of Hydromechanics and Modelling of Hydrosystems, University of Stuttgart, Stuttgart, Germany

Drinking-water well catchments include many sources for potential contaminations like gas stations or agriculture. Finding optimal positions of monitoring wells for such purposes is challenging because there are various parameters (and their uncertainties) that influence the reliability and optimality of any suggested monitoring location or monitoring network. The goal of this project is to develop and establish a concept to assess, design, and optimize early-warning systems within well catchments. Such optimal monitoring networks need to optimize three competing objectives: (1) a high detection probability, which can be reached by maximizing the “field of vision” of the monitoring network; (2) a long early-warning time such that there is enough time left to install countermeasures after first detection; and (3) the overall operating costs of the monitoring network, which should ideally be reduced to a minimum. The method is based on numerical simulation of flow and transport in heterogeneous porous media coupled with geostatistics and Monte-Carlo, wrapped up within the framework of formal multi-objective optimization. In order to gain insight into the flow and transport physics and statistics that control the optimality of monitoring wells, and thus in order to perform the optimization in a more formal targeted manner, we first use an analytical model based on the 2D steady-state advection-dispersion equation. Monte-Carlo simulation techniques are applied to represent parametric uncertainty. From this, we can obtain maps of contaminant detection probability for all possible placements of one individual monitoring well. Its optimal position is defined by the highest detection probability and describes a limit for meaningful solutions considering additionally early-warning time. Thus, a significant number of potential positions can be excluded from the optimization of entire networks, improving the computational efficiency of network optimization. Finally, we demonstrate that the individual well optima can indeed be found to be part of the results.

Felix Bode, Department of Hydromechanics and Modelling of Hydrosystems, University of Stuttgart, Stuttgart, Germany

Felix Bode is a Ph.D. student in the Department of Hydromechanics and Modelling of Hydrosystems at the University of Stuttgart (Germany). From October 2007 to January 2013 he studied

Environmental Engineering at the University of Stuttgart.

Philip Binning, Department of Environmental Engineering, Technical University of Denmark, Lyngby, Denmark

Philip Binning is a Professor and Head of the Education Department of Environmental Engineering at the Technical University of Denmark.

Wolfgang Nowak, Department of Hydromechanics and Modelling of Hydrosystems, University of Stuttgart, Stuttgart, Germany

JWolfgang Nowak, M.Sc. University of Stuttgart (Germany), Department of Hydromechanics and Modelling of Hydrosystems.

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